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US 4633982 A

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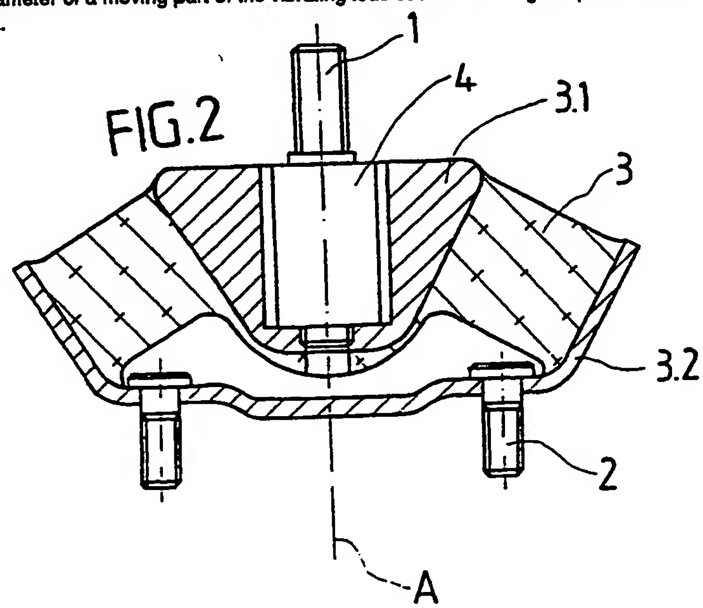
(54) Motor vehicle engine mounting

(57) An elastic mounting comprises an elastic rubber spring member (3) located between two connecting members (1, 2) in order to support a vibrating load whose vibration spectrum includes both low frequency and high frequency vibrations, in particular motor vehicle engine mountings. The spring member (3) is fitted with an electrostrictive or magnetostrictive actuator (4) in a mechanical arrangement in series. A sensor detects the alternating forces, alternating accelerations or vibrational displacements due to the vibrating load and is connected to the actuator (4) via an amplitude and phase regulator and amplifier wherein the regulation is so designed that the actuator (4) minimises the alternating forces, alternating accelerations and vibrational displacements applied to the sensor. The sensor may instead detect a characteristic parameter of a moving part of the vibrating load such as the angular position and/or rotation speed of an engine crankshaft.

FIG.2



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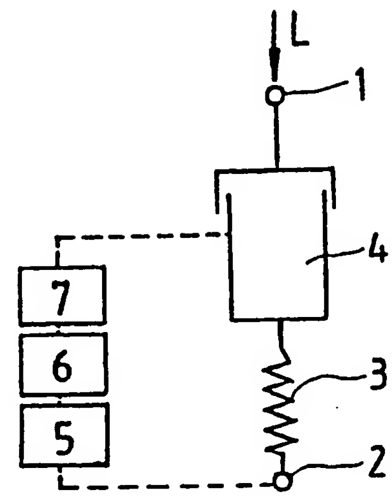

FIG.1a

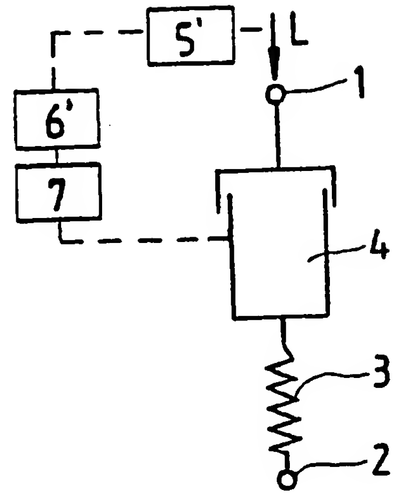

FIG.1b

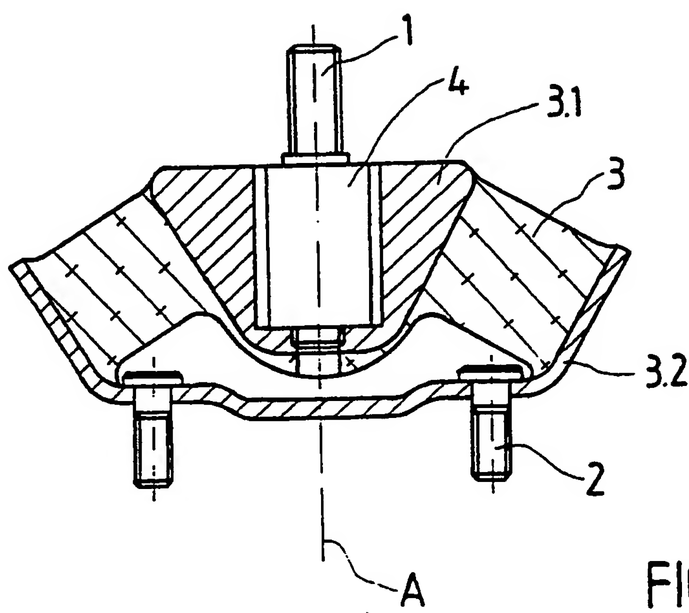

FIG.2

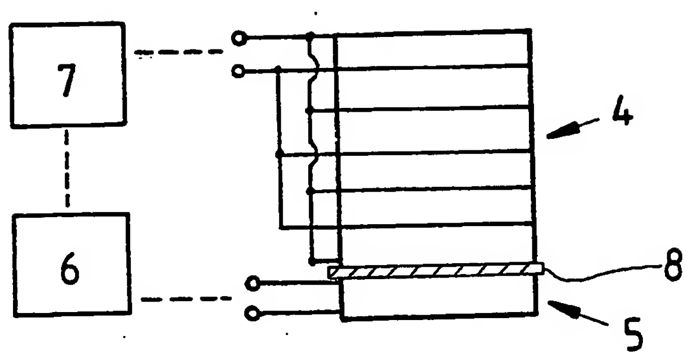

FIG.3

ELASTIC MOUNTING, IN PARTICULAR A MOTOR VEHICLE ENGINE MOUNTING

The invention relates to an elastic mounting with an elastic rubber spring member located between two connecting members in order to support a vibration load, whose vibration spectrum includes both low frequency and high frequency vibrations, in particular motor vehicle engine mountings.

Such engine mountings are known in a large number of different forms. Their function is basically to prevent the movements of a vibrating load being transmitted to the foundation or frame supporting this load, and this is achieved in different ways and with varying degrees of success by different forms of mounting. Although previously predominantly pure rubber mountings in which the induced vibration amplitudes were only reduced by the internal damping of the rubber pad were used, now mountings with integrated damping devices are preferred, such as those described in the form of a "hydromounting" in DE-PS 32 07 553 and a "displacement mounting" described in DE-PS 32 33 456. In addition to vibration insulation and damping the forms illustrated in the two documents mentioned also offer the advantage that they process imposed vibrations selectively, namely in such a way that low frequency vibrations, i.e. vibrations with frequencies below some 20 Hz, which generally have a large amplitude, are strongly damped, while high frequency vibration, i.e. vibrations over some 20 Hz, which generally have a smaller amplitude, but are a considerable nuisance because of their acoustic effect, are taken up virtually undamped and thereby largely isolated from the foundation or frame.

Although this acoustic insulation already satisfied very extensive requirements in the case of known hydromountings and displacement mountings, as a result of further increase in demand for comfort the fundamental object of this invention is to provide an elastic mounting which optimised the transfer of high frequency, and in particular acoustically undesirable, vibrations by means of flexible adjustment and active control of the resulting spring forces taking up the vibrating load. The fulfilment of this object was of particular importance in the case of motor vehicle engine mountings.

According to the present invention there is provided an elastic mounting with an elastic rubber spring member located between two connecting members in order to support a vibrating load, whose vibration spectrum includes both low frequency and high frequency vibrations, in particular motor vehicle engine mountings, in which the spring member is fitted with an electrostrictive or magnetostrictive actuator in a mechanical arrangement in series and in which a sensor which detects up the alternating forces, alternating accelerations or vibrational displacements due to the vibrating load is provided and is connected to the actuator via an amplitude and phase regulator and amplifier wherein the regulation is so designed that the actuator minimises the alternating forces, alternating accelerations and vibrational displacements applied to the sensor.

Also in accordance with the present invention there is provided an elastic mounting with an elastic rubber spring member located between two connecting

members in order to support a vibrating load whose vibration spectrum includes both low frequency and high frequency vibrations, in particular motor vehicle engine mountings, in which the spring member is fitted with an electrostrictive or magnetostrictive actuator in a mechanical arrangement in series and in that a sensor which detects a characteristic movement and positional parameter of periodically moving parts of the vibrating load, such as e.g. the angular position and/or the rotation speed of a motor vehicle engine crankshaft, is provided and is connected via a computer and an amplifier to actuator, wherein a program processing the output signal of the sensor on the basis of an empirically determined vibration characteristic of the load is stored in the computer and wherein the computer output signal applied to the actuator via the amplifier controls the latter in such a way that it brings about a reduction in the alternating forces, alternating accelerations and vibrational displacements occurring in the frame or base-side connecting member.

In accordance with the invention it is proposed to incorporate electrostrictive or magnetostrictive "actuators" in order to achieve the specified tasks. These actuators are known in themselves, and it has already been proposed that they should be incorporated as components of fine mechanical tools and processing machinery. They have the advantageous property that their axial length varies in relation to the voltage applied to them or the current flowing through them so that with their help electrical signals can be converted directly into mechanical movements. In the context of this invention electrostrictive actuators which are based on the known piezoelectric principle are preferred.

In the elastic mounting according to the invention an actuator of this kind forms a mechanical in series connection with an elastic rubber spring member and for the purpose of its control it is connected to a sensor which provides, in a first preferred embodiment of the invention in association with a regulator device and in a second embodiment of the invention in association with a computer, control signals which correspond to the alternating forces or vibrational movements produced by the vibrating load and through which its axial length is so continuously changed that the said alternating forces and vibrational movements are at least partially compensated and taken up and thus in any event are transmitted in greatly reduced measure to the foundation or frame.

In this way the actuator deadens in particular high frequency acoustic vibrations of low amplitude while low frequency large amplitude vibrations are taken up by the spring member and may be damped. On account of the small amplitudes of the undesirable acoustic vibrations, which in general are only of a few tenths of a millimetre, the changes in length which can be achieved in available actuators which are of the same order of magnitude are fully sufficient for effective body noise insulation.

In the abovementioned preferred first embodiment of this invention the alternating forces or vibrational movements produced by the vibrating load are taken up by electrical sensors in the form of force or movement acceptors, in particular sensors incorporated in the mounting, the output signal from which controls the

actuator by means of a known control device and amplifier. Thus the control device and amplifier, the actuator and the sensor form a closed control loop in which the actuator acts as the regulating member and the sensor acts as the detector. The alternating forces or vibrational displacements applied to the sensor enter this control loop as an error quantity, the actual value of the error quantity being compared with the specified reference quantity, in particular "zero", and the adjusting member being activated in such a way that the actual value is brought closer to this reference value with the result that the error quantity is minimised and in particular reduced to "zero".

Piezoelectric units are preferably used as electrical sensors for this purpose. Alternatively sensors, in particular of the strain measuring type, may be considered.

The sensors are preferably incorporated as close as possible to the unit comprising the rubber spring member and the actuator in order to avoid influence from interfering vibrations from other sources which cannot be controlled with the help of the actuator. In a particularly advantageous embodiment the actuator and the sensor are mounted together in a unit formed of disc-shaped piezo elements stacked together in the direction of the axis of the mounting or in the direction of vibration of the load, wherein the piezo elements of the actuator are connected together electrically in parallel and are insulated electrically from the piezo element of the sensor.

In order that the advantageous effects achieved with the invention are not only utilised in a single vibrational direction, in a preferred embodiment, each main vibrational direction of the load applied to the mounting according to the invention is provided with an actuator and a corresponding sensor. Preferably the arrangement of the actuators and sensors is in the form of three projections at right angles to each other.

In the abovementioned second embodiment of the invention an elastic mounting which utilises one of the stated advantages of actuators is proposed, in which the incorporated sensor is a detector which detects characteristic movement and positional parameters of the periodically moved components of the load applied to such a mounting which are directly or indirectly associated with the cause of the vibration in the load. In the case of a mounting for a motor vehicle engine a suitable detector may for example detect the angular position and rotation speed of the crankshaft. The signal produced by the detector is passed to a computer which is connected to the actuator through an amplifier.

The computer then controls the actuator in relation to the phase signal detected (e.g. the angular position of the crankshaft) in accordance with a stored program which has been established on the basis of investigation of the vibration characteristics of the load in such a way that the in particular high frequency alternating forces and vibrational movements applied to the mounting are largely compensated and taken up. Here it may also be advantageous to provide actuators in the

main direction of vibration of the system, in particular actuators in the form of three projections at right angles.

In all embodiments of the elastic mounting according to the invention the spring member used preferably has a damping device and in particular is designed so that the spring member consists not of a pure rubber mounting but of a hydromounting or displacement mounting of the known type described in the introduction.

The present invention will be further illustrated, by way of example, with reference to the accompanying drawings, in which:

Fig. 1a is a diagrammatical view of a preferred arrangement of the preferred first embodiment of the elastic mounting according to the invention with controlled actuator control;

Fig. 1b is a corresponding illustration of a preferred arrangement of the second embodiment described above;

Fig. 2 is an axial view through a practical preferred arrangement; and

Fig. 3 is a diagrammatical view of the structural member which can be used in the first embodiment in which the actuator and sensor are advantageously incorporated together.

As Fig. 1a shows, in an elastic mounting according to the invention has an elastic spring member 3 and an actuator 4 are mounted mechanically in series between connecting member 1 to which the vibrating load L is applied and the base or frame-side connecting member 2. Sensor 5 is mechanically connected in the vicinity of connecting member 2 and its output signal is processed by connected computer 6 and amplifier 7 in such a way that it adjusts actuator 4, the adjustment being designed so that the alternating forces produced by vibrating load L are taken up by the actuator 4 without passing through connecting member 2 to which sensor 5 is coupled.

Fig. 1b shows in a corresponding diagrammatical presentation an elastic mounting of the second embodiment according to the invention with a mechanical connection in series with spring member 3 and actuator 4 fitted with a detector 5', which is used as the sensor which determines the phase position and rotation speed of a periodically moved part of load L (for example the crankshaft of a motor vehicle engine) and passes it to a computer 6'. Computer 6' then controls actuator 4 via amplifier 7 in relation to the sensor signal on the basis of an empirically determined program stored within it, in which each vibrational state of load L is associated with an actuator control voltage, whereby the axial length of actuator 4 is altered so that it continuously compensates for or largely reduces the alternating forces, alternating accelerations or vibrational movements applied to the mounting.

Fig. 2 illustrates the invention for the practical embodiment of a simple rubber engine mounting. Actuator 4 bears on its upper side connecting member 1

which is connected to the engine and on its lower side is supported on an intermediate member 3.1 which is vulcanised together with rubber spring member 3. The opposite side of rubber spring member 3 is vulcanised together with intermediate member 3.2 which forms a stiff unit with frame-side connecting member 2.

As may be deduced directly from Fig. 2 by one skilled in the art members 3, 3.1 and 3.2 may be advantageously replaced by a "hydromounting" (e.g. in accordance with DE-PS 34 07 553) or a "displacement mounting" (e.g. in accordance with DE-PS 32 33 456), thus also utilising their selectively damping effect.

While in Fig. 2 the arrangement and nature of the sensor is left open Fig. 3 shows in the context of the invention in the embodiment according to Fig. 1a a particularly advantageous combination of an actuator 4 comprising disc-shaped piezo elements and a sensor 5 likewise consisting of a disc-shaped piezo element which are brought together to form a compact structural unit. The disc-shaped piezo elements form a coaxial stack in which the piezo elements of actuator 4 are connected together electrically in parallel and are electrically isolated from the piezo element of sensor 5 by an insulating layer 8. Actuator 4 and sensor 5 in this structural member form a closed control loop together with regulator 6 and amplifier 7 in an elastic mounting according to the invention, as described in the above.

CLAIMS

1. An elastic mounting with an elastic rubber spring member located between two connecting members in order to support a vibrating load, whose vibration spectrum includes both low frequency and high frequency vibrations, in particular motor vehicle engine mountings, in which the spring member is fitted with an electrostrictive or magnetostrictive actuator in a mechanical arrangement in series and in which a sensor which detects up the alternating forces, alternating accelerations or vibrational displacements due to the vibrating load is provided and is connected to the actuator via an amplitude and phase regulator and amplifier wherein the regulation is so designed that the actuator minimises the alternating forces, alternating accelerations and vibrational displacements applied to the sensor.

2. An elastic mounting as claimed in claim 1, in which the sensor is coupled to the frame or a base-side coupling member.

3. An elastic mounting as claimed in claim 1 or 2, in which the sensor is a piezoelectric sensor.

4. An elastic mounting as claimed in claim 1 or 2, in which the sensor is constructed in the form of a strain measuring strip.

5. An elastic mounting as claimed in any preceding claim in which the actuators and sensors are directed in the main of directions of vibration of the supported vibrating load.

6. An elastic mounting as claimed in claim 5, in which the mounting incorporates three actuators and sensors in the form of three arms at right angles to each other.

7. An elastic mounting as claimed in any preceding claims in which the actuator and the sensor are mounted together in a structural member formed of disc-shaped piezo elements stacked on top of each other in the direction of the axis of the mounting or in the direction of vibration of the load, wherein the piezo elements of the actuator are connected together electrically in parallel and are electrically isolated from the piezo element of the sensor.

8. An elastic mounting with an elastic rubber spring member located between two connecting members in order to support a vibrating load whose vibration spectrum includes both low frequency and high frequency vibrations, in particular motor vehicle engine mountings, in which the spring member is fitted with an electrostrictive or magnetostrictive actuator in a mechanical arrangement in series and in that a sensor which detects a characteristic movement and positional parameter of periodically moving parts of the vibrating load, such as e.g. the angular position and/or the rotation speed of a motor vehicle engine crankshaft, is provided and is connected via a computer and an amplifier to actuator, wherein a program processing the output signal of the sensor on the basis of an empirically determined vibration characteristic of the load is stored in the computer and wherein the computer output signal applied to the actuator via the amplifier controls the latter in such a way that it brings about a

reduction in the alternating forces, alternating accelerations and vibrational displacements occurring in the frame or base-side connecting member.

9. An elastic mounting as claimed in any preceding claim in which the spring member is provided with a damping device.

10. An elastic mounting as claimed in claim 9, in which the spring member is constructed as a known "hydromounting" or "displacement mounting".

11. An elastic mounting, substantially as hereinbefore described with reference to the accompanying drawings.

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Applic. #___________________________

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